Appendix K – Compliance Monitoring Protocol

INTRODUCTION AND BACKGROUND

Following issuance of the Incidental Take Permit (ITP), MidAmerican Energy Company (MidAmerican Energy or MidAmerican) will conduct compliance monitoring at the Projects to monitor bat and eagle mortality and to ensure the levels of estimated take of the Covered Species remain within the levels of take authorized by the ITP. The overall goal of the ITP compliance monitoring is to determine reliable and repeatable (annual) estimates of all bat and eagle mortality from which the estimated incidental take of the Covered Species can be calculated.

MidAmerican conducted extensive monitoring studies at the Projects between December 2014 and November 2016 to evaluate bat and eagle mortality, and continued monitoring at 10 Projects through March 2017 to complete its evaluation of eagle mortality. These monitoring studies ensure that MidAmerican's Habitat Conservation Plan (HCP) is supported by Project-specific data, including the ITP compliance and effectiveness monitoring program.

The compliance monitoring program was designed based on evaluation of the 2014-2017 studies, available information, U.S. Fish and Wildlife Service (USFWS) HCP guidance, and the ITP compliance needs with the following objectives in mind:

- A monitoring plan designed to facilitate evaluation of thresholds that would indicate whether and when an adaptive management response or changed circumstances provisions may be needed to maintain permit compliance;
- A comprehensive system using operations, maintenance and other staff at the Projects;
- A monitoring plan scaled to the geographic scope of the HCP;
- A monitoring plan that would provide MidAmerican the ability to react to results; and
- A cost-effective strategy that would provide the metrics necessary to monitor take of the Covered Species.

MONITORING PLAN

The Informed Evidence of Absence (IEoA) model uses both the Evidence of Absence (EoA) and Species Composition (SC) estimates for the Covered Bat Species (see details in Appendix D and Addendum 1 of this appendix). The IEoA approach amalgamates information from two separate approaches (EoA and SC), thus improving accuracy and precision of Covered Bat Species' fatality estimates.

At the end of each monitoring period, the EoA estimate and the SC estimate will be calculated for each Project based on carcasses of the Covered Bat Species and all bat species found during monitoring and corrected for sources of bias, including searcher efficiency, carcass removal, and unsearched areas. The annual all bat fatality rate will be estimated by adjusting the monitoring period estimate to account for bat mortality during the remainder of the bat active period (approximately March 15 through November 15). The total estimated number of the Covered Bat Species is then calculated using the IEoA model.

The goal of the ITP compliance monitoring is to determine reliable and repeatable estimates of Covered Bat Species and eagle mortality from which the estimated incidental take of the Covered Species can be calculated. For the Covered Bat Species, the IEoA approach was chosen for the compliance monitoring for the following reasons:

- It provides the results and information necessary to monitor and track compliance with the ITP;
- It aligns the ITP compliance monitoring with the original methods for estimating take used in the HCP; and
- It takes advantage of the large baseline data from the MidAmerican Projects to help improve the precision and economics of the monitoring and subsequent take estimate. All bat fatalities, species compositions, searcher efficiency and carcass removal, search area, and timing of bat fatalities are all used to help inform the compliance monitoring estimates.

For eagles, the carcasses detected during monitoring will provide a close measure of likely take numbers after adjusting for searcher efficiency, carcass removal, and viewable area because discovery probabilities are relatively high. The estimates of annual take for the Covered Bat Species and eagles can be tracked over time and compared to the original take prediction and the ITP take limit.

Monitoring Schedule

ITP compliance monitoring will occur on an annual basis for the term of the permit. Operations and maintenance (O&M) technicians will search all turbines at a minimum interval of once per month year-round during routine turbine maintenance. For the Covered Bat Species, additional monitoring will occur each year between July 1 and October 15 as further described below. This period corresponds to the period of highest observed bat mortality based upon monitoring studies conducted at the projects.

Bat Monitoring Plan

MidAmerican Energy will monitor all bat mortality at the Projects during the term of the ITP according to the following provisions. The Bat Monitoring Protocol (see below) provides details of the monitoring scope and methods developed in coordination with the USFWS and will be implemented annually upon ITP issuance.

The monitoring protocol for bats includes the following measures:

- Baseline post-construction monitoring data from 2015 and 2016 and the Iowa Department of Natural Resources (IDNR) 2016 migration study results were used to define the season of highest expected bat mortality, which will constitute the annual bat monitoring period. This approximately 15-week period runs from July 1 to October 15 each year, based on results from 2015 and 2016, which indicate that the greatest number of all bat fatalities and *Myotis* bat fatalities occur in this period.

- MidAmerican O&M technicians will be trained in carcass search and identification methods, including how to conduct searches of the plot, how to record that the search was conducted, how to record data on any finds, how to collect and store any finds, and whom to notify of any finds. Alternatively, MidAmerican may choose to contract with a qualified third party contractor for conducting the Annual Monitoring. All bat carcasses found will be retained and provided to USFWS for species identification verification.
- MidAmerican will establish search plots on the turbine pad and access roads out to a maximum distance of 100 meters (m; 328 feet).
- O&M technicians or separately contracted staff will conduct road-and-pad searches at all turbines at each Project once per week during the defined annual bat monitoring period.
- Consideration for the sources of potential error in estimating all bat mortality: searcher efficiency, carcass removal, area correction, and annual correction.
- Searcher efficiency will be measured annually during the 15-week bat monitoring period.
- Carcass removal rates will also be checked annually during the 15-week bat monitoring period.
- Results obtained from 2015 and 2016 bat post-construction monitoring studies will be used to establish the area correction for each Project.
- The all bat mortality estimate for the 15-week annual bat monitoring period will be extrapolated to the entire bat active season based on ratios of the annual bat monitoring period to the entire bat season to develop an all bat mortality estimate. This estimate is used to determine the SC prior that will be used in the IEoA analysis.

Bat Monitoring Protocol

<u>Standardized Carcass Searches</u>

Standardized carcasses searches for bat carcasses[1] will be completed at all turbines at all Projects. Carcasses found during the study could be found by: (1) searchers during scheduled searches, (2) searchers outside of search plots, (3) searchers within search plots outside of scheduled searches, or (4) facility personnel or others on site for other purposes, such as facility maintenance. All carcasses found within a search plot during or outside of a scheduled search within the study period will be included in the analysis of the fatality estimates. For those carcasses found outside scheduled searches but within a search plot, it is assumed that they would have been found during the next scheduled survey. Carcasses found outside of search plots or outside of the study period will be documented as incidentals but not included in analysis of the all bat fatality estimates. In the event that a Covered Bat Species carcass is found outside the search plot or outside the study period it

1 Carcass is defined as an injured or dead bat.

will be included in updating the species composition ratios and the covered species estimates which will be used in the IEoA method when calculating the take estimates.

Search Plot, Timing, Sample Size, and Search Interval

Searches will be conducted on a weekly basis from July 1 through October 15 each year. The search plot will include the turbine road and pad which will include the entire gravel turbine pad and all gravel access roads within a 100-m radius of the turbine. This is similar methodology to other fatality studies in the Midwest that are searching turbine roads and pads, and is consistent with the surveys conducted in 2015 and 2016. It has been demonstrated that greater than 80% of bat fatalities fall within half the maximum distance of turbine height to ground (Arnett et al. 2005, 2008). A100-m radius plot is greater than one-half the maximum height of the Project turbines, so will encompass the area where greater than 80% of bat carcasses are expected to fall. For any given search, searchers will walk the perimeter of the entire the road and around the turbine pad while focusing search efforts for carcasses on the roads and pads.

Data Collection

All bat carcasses found will be recorded using the methods described below. Cause of death will be determined, if possible, based on field inspection; however, due to the difficulty associated with obtaining accurate estimates of natural or reference mortality, the conservative assumption will be made that all carcasses found in search plots were attributable to turbine collision.

Date, start time, end time, observer, turbine number, and weather data will be recorded for each search. When a bat carcass is found, the observer will record the distance the observer is from the carcass when first observed. Observers will place a flag near the carcass and continue the search. After searching the entire road and pad plot, the observer will return to each carcass found and record information on a fatality data sheet, including the date, observer, turbine number, species, sex and age (when possible), distance and direction from turbine, Universal Transverse Mercator (UTM) coordinates, visibility class, condition (e.g., intact, scavenged, partial), and estimated time of death (e.g., less than one day, two days, etc.). Digital photographs will be taken of the carcass, any visible injuries, and surrounding habitat. Rubber gloves will be used to handle all carcasses to eliminate possible transmission of diseases and to reduce any possible human scent bias for carcasses later used in scavenger removal trials. Bat carcasses found will be placed in a plastic bag and labeled with a unique number, and stored in a freezer on site for future reference and possible further study. A copy of the data sheet will be maintained with the bat carcass at all times. All *Myotis* bat fatalities found will be retained, and not used in trials for expansion factors (see below), for species verification either by another expert or through genetic analysis.

Carcasses found in the non-search area or found outside of the scheduled search time will be coded as incidental discoveries and will be documented in a similar fashion as those found during standard searches. Incidental discoveries found outside of scheduled search plots will not be included in the calculation of fatality estimates, but will be included in reporting on appropriate topics such as species composition.

Expansion Factors

Searcher Efficiency Trials

The objective of the searcher efficiency trials is to estimate the percentage of casualties that are found by searchers. Searcher efficiency trials will be conducted in the same areas carcass searches occur. Trials will be conducted to cover all facilities. Estimates of searcher efficiency will be used to adjust the total number of carcasses found for those missed by searchers in order to correct for detection bias. Trials will be conducted annually.

All trial carcasses will be placed at locations within areas being searched prior to the carcass search on the same day. Carcasses will be dropped from shoulder height and allowed to land in a random posture. Each trial carcass will be discreetly marked with a black zip-tie around the upper arm so that the bat can be identified as a trial carcass if it is found by other searchers or wind facility personnel. The number and location of detected trial carcasses found during the carcass search will be recorded. The number of carcasses available for detection during each trial will be determined immediately after the trial by the person responsible for distributing the carcasses.

Carcass Removal Trials

The objective of carcass removal trials is to estimate the likelihood a carcass is removed by scavengers, measured as a function of the number of days since the trial carcasses were placed in the field. Carcass removal includes removal by predation/scavenging or removal by other means, such as being plowed into a field. Carcass removal studies will be conducted annually during the 15-week study period. Estimates of carcass removal will be used to adjust the total number of carcasses found for those removed from the study area, correcting for removal bias.

Carcasses will be dropped from shoulder height and allowed to land in a random posture. Each trial carcass will be discreetly marked with a black zip-tie around the upper arm f so that it can be identified as a study carcass if it is found by other searchers or wind facility personnel.

Personnel conducting carcass searches will monitor the trial bat carcass over a 14-day period, adhering to the following schedule as closely as possible. Carcasses will be checked every day for the first four days, and then on days seven, 10, and 14. This schedule may vary depending on weather conditions and coordination with the other survey work. Experimental carcasses will be left at the location until the end of the carcass removal trial. At the end of the 14-day period, any evidence of the carcasses that remain will be removed. In the event that bat carcasses are not available for the trials, dark-colored mice will be used as a surrogate.

Statistical Analysis

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures will be implemented at all stages of the study, including in the field, during data entry and analysis and report writing. For example, a sample of records from an electronic database will be compared to the raw data forms and any errors detected will be corrected.

All Bat Fatality Rate Estimation

Fatality estimation is a complex task due to a number of variables present in the study. Animals die at an unknown rate, persist for variable amounts of time and can be detected with varying levels of success based on searcher efficiency, carcass characteristics and ground cover. To account for these variables, fatality rate estimation methods have been developed.

All bat estimates of facility-related fatalities are based on:

1) Observed number of carcasses found during standardized searches during the intensive period;
2) Searcher efficiency expressed as the proportion of placed carcasses found by searchers during searcher efficiency trials;
3) Removal rates expressed as the estimated average probability a carcass is expected to remain in the study area and be available for detection by the searchers during removal trials; and
4) Search area adjustment based on the plot size and carcass density based on previous monitoring data.

The total number of fatalities will be estimated by adjusting for searcher efficiency, carcass removal, and area correction expansion factors via a fatality estimator model. The Huso estimator[2] will be used to estimate fatality rates and is described below.

Definition of Variables

The Huso estimator will be used to estimate all bat mortality which is integral to the SC method estimates used in the IEoA analyses. The following variables are used in the equations below for the Huso estimator (Huso 2010, Huso et al. 2012):

- N total number of turbines at the Project(s)
- n number of turbines sampled at the Project(s)
- $\hat{a}_i$ density weighted area correction for category *i*
- I_i time interval between the previous search and discovery for category *i*
- $\hat{\hat{I}}_i$ effective search interval for carcasses in category *i*
- $\hat{r}_i$ average probability of persistence for carcass in category *i*
- $\hat{p}_i$ probability of detection for carcass in category *i*
- c_i total number of carcasses in category *i*

Estimation of Searcher Efficiency Rates

Searcher efficiency rates are estimated using a logistic regression, which models the natural logarithm of the odds of finding an available carcass as a function of the above covariates. The best model will be selected using an information theoretic approach known as AICc, or corrected Akaike Information Criteria (Burnham and Anderson 2002).

Estimation of Carcass Removal Rates

Estimates of carcass removal rates are used to adjust carcass counts for removal bias. The average probability of persistence of a carcass, $\hat{r}$, is estimated from an interval censored carcass persistence model. Exponential, log-logistic, lognormal, and Weibull distributions are fit and the best model is selected using AICc.

Area Correction Calculation

The area searched underneath turbines typically represents a sample of the area in which carcasses could land. To account for unsearched area – either as a result of searches

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2 Other estimators may be evaluated for use.

restricted to roads and pads, or carcasses that could have fallen beyond the plot boundaries – models of carcass density (with respect to distance from the turbine base) can be used to calculate the density-weighted proportion of area searched (DWP).

Bat carcass information from the 2015 and 2016 monitoring periods were used to fit a density model. Searched area was weighted as a function of distance from the turbine, because the areas near the turbine tend to have a higher density of bat carcasses than areas farther from the turbine (Huso and Dalthorp 2014). The result is an estimate of the proportion of bat casualties expected to land within searched and unsearched areas around turbines. During ITP monitoring, this area correction factor will be computed using the Truncated Weighted Likelihood Method (TWLM) outlined in Addendum 2 of Appendix D.

The results from the University of Iowa ballistic model will be used to inform or corroborate the DWP to the extent possible.

Adjusted Facility-Related Fatality Rates
The estimated probability that a carcass in category *i* was available and detected is:

$$\widehat{\pi_i} = \widehat{a_i} \cdot \widehat{p_i} \cdot \widehat{r_i} \cdot \hat{v}_i$$

where $\widehat{v_i}$ = min(1, $\hat{\tilde{I}}_i/I_i$). Thus, the total number of fatalities in category *i*, based on the number of carcasses found in category *i* is given by:

$$\widehat{m_i} = \frac{c_i}{\widehat{\pi_i}}.$$

The total per turbine fatality rate *(m)* is estimated by:

$$\hat{F} = \frac{\sum_{i=1}^{k} \widehat{m}_i}{n}$$

The per-turbine fatality rate point estimates will be calculated using the above formulae. Standard errors and 90% confidence intervals will be calculated using bootstrapping (Manly 1997). Bootstrapping is a computer simulation technique that is useful for calculating point estimates, variances, and confidence intervals for complicated test statistics. A total of 1,000 bootstrap samples are planned to be used. The standard deviation of the bootstrap estimates is the estimated standard error. The lower 5^{th} and upper 95^{th} percentiles of the 1,000 bootstrap samples will be estimates of the lower limit and upper limit of 90% confidence intervals.

Estimates of Take for Covered Bat Species

The IEoA analytical method (see HCP Appendix D for more detail) will be used to estimate annual take of the Covered Bat Species. The IEoA approach uses estimates of covered species mortality from the SC approach to inform the prior distributions of both *M* (past cumulative take) and λ (take rate used in future predictions) in the EoA approach.

Information used to inform the IEoA approach will be compute from past information only. That is, prior information for year *j* will come from years 1 through *j*-1.

Eagle Monitoring Plan

Based on eagle use data collected thus far, the high risk period for eagle fatalities at the Projects is approximately November 1 through March 31, though searches will be conducted monthly unless prohibited by crop growth. Given minimal vegetation cover, eagle carcasses are highly visible during much of this period and eagle carcasses are expected to persist on the landscape for relatively long periods. The results of the eagle monitoring searches will be adjusted for searcher efficiency and carcass removal as described below to determine an annual estimate of total eagle mortality.

The monitoring protocol for eagles includes the following measures:

- MidAmerican will train O&M technicians in carcass search and identification methods.
- Trained O&M technicians will scan roads, pads, and a surrounding 100-m radius plots at each wind turbine at each Project every month. Only the roads and pads will be scanned during the time period when crops are present.
- When an O&M technician visits a turbine for regular maintenance, the technician will spend five minutes at each turbine visually scanning the road and pad and area surrounding the turbine in each of the four cardinal directions from the turbine base for eagle carcasses.
- MidAmerican will measure searcher efficiency of O&M technicians during the first year of the permit term at each Project, and thereafter at 5-year intervals. Searcher efficiency estimates will be used to adjust take estimates. Due to the size of eagle carcasses, searcher efficiency is high and not expected to vary annually.

Disposition of Data and Reporting

MidAmerican Energy will prepare a protocol, data sheets, and report templates for the Annual Monitoring that will be reviewed and approved by the USFWS prior to initiation of the first year of monitoring under the ITP. Raw data forms will be stored onsite at each Project's O&M facility; completed data forms will be collected by November 30 each year to be incorporated in annual reports. Raw data forms will be made available to the USFWS upon request. If necessary for further species identification of potential Covered Bat Species, individual carcasses collected will be housed in a freezer located at the Project's O&M facility. The following information will be maintained for each Project in a database that will be provided to the USFWS annually or upon request: date and time of collection, species, UTM coordinates, closest turbine number, and, if available, temperature and wind speed for a period preceding a Covered Species fatality.

The USFWS and IDNR will be notified (by email and/or phone) within 48 hours of positive identification of any Covered Species carcasses discovered at the Project. The USFWS and IDNR will also be notified (by email and/or phone) within 48 hours of positive identification of any other eagle or federally or state threatened or endangered species carcasses are discovered. The final disposition of individual carcasses of these species will be based on the legal status of the species and at the direction of the USFWS.

An annual Monitoring Report describing methods and results of the compliance monitoring for all Projects will be prepared following completion of the field surveys and data analysis for each year of monitoring. Reports will be submitted to the USFWS by April 1 each year. The Annual Monitoring Report will include the following information:

- Monitoring study results, including results of any bias corrections (i.e., searcher efficiency trials, carcass removal trials, and search area corrections), estimates of total bat mortality, and estimates of take of the Covered Species;
- Every five years a determination of whether an adaptive management trigger has been met and therefore a response should be implemented and recommended adaptive management changes to be implemented the following year, if necessary;
- Summary of the field data collected for all bat and eagle fatalities; and
- Summary of turbine operations showing at a minimum the turbines' rotor revolutions per minute as a function of wind speeds to show that turbines were operating appropriately and feathering of turbine blades was in effect during the minimization period (see Section 5.3.2 of the HCP).

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ADDENDUM 1 – METHOD FOR UPDATING SPECIES COMPOSITION RATIO

Objective

This addendum describes a method for estimating and updating species composition ratios from past and present monitoring data. The species composition ratios inherent in the SC estimates of rare bat fatalities will be updated annually based on recent past monitoring data. The update method takes a prior set of species composition ratios, and updates them annually with field data collected at one or multiple wind power generation facilities. In the remainder of this Addendum, the methods are justified, the exact updating scheme is described, and a hypothetical example is included.

Methods

The SC ratio updating method is part Bayesian because it assumes a conjugate prior (defined below) distribution for species ratios and calculates posterior estimates after field data are incorporated. The method is part weighted average because past years are given declining weights in the Bayesian updating method.

Theory behind the Bayesian updating of species composition ratios is as follows. The set of species ratios is denoted as

$$\Pi = [\pi_1, \pi_2, \dots, \pi_K],$$

where each entry is the ratio of a particular species in the study area of interest. For MidAmerican, this vector could contain one ratio for all bat species in Iowa, but for simplicity is defined to contain four ratios for the Covered Species (INBA, NLBA, TRBA, LBBA) and a fifth for all other bat species (OTHER). The initial ratios in Π will be computed as simple ratios from appropriate prior information, i.e.,

$$\pi_i = \frac{c_i}{\sum_{j=1}^{K} c_j}$$

where c_i is called the 'pseudo-count' of species i in the prior data set. Pseudo-counts do not need to be integers, and must be > 0 if a species is at risk of fatality in an area, even if it has not been observed. Note that $\sum_{i=1}^{K} \pi_i$ = 1.0. Appropriate prior information comes from similar wind power facilities in the region. The initial set of prior species ratios for MidAmerican facilities was computed using public wind power monitoring data sets located in the state of Iowa (Table 1). Prior pseudo-counts were adjusted upward by 0.5 to ensure initial $\pi_i > 0$ for all species. Had an INBA mortality been observed in the prior data set for MidAmerican, this step would not have been necessary. If appropriate prior data had not been available, a reasonable uninformed prior assumption would be to use pseudo-counts of 0.5 for all species involved.

Bayesian estimation theory updates the initial Π after field data is collected. Field data is represented by the vector $Y = [y_1, y_2, \dots, y_K]$, where y_i is the carcass count of species i in field data collected over some time period. Note that any y_i in Y could equal zero, and that the sum of all y_i's is the total number of carcasses actually found during that year's field season. We condition on total carcass count and assume Y follows the multinomial distribution, i.e.,

$$[y_1, y_2, \dots, y_K] \sim Multinomial(\pi_1, \pi_2, \dots, \pi_K)$$

This establishes the connection between the true species composition ratios in Π and observed carcass counts Y.

To obtain updated composition ratio estimates, it was assumed Π is a multivariate random variable and that it follows the multivariate analog of the Beta distribution. That is, it was assumed Π follows a $Dirichlet(c_1, c_2, \dots, c_K)$ (Wikipedia contributors, 2016) distribution. The Dirichlet distribution is the ***conjugate*** prior (Wikipedia contributors, 2017) distribution for the multinomial (Tu, 2016). Because of this, the posterior distribution of Π is exactly the same as the prior (i.e., Dirichlet), and this greatly simplifies updating of point estimates. The posterior distribution of Π assuming a Dirichlet prior is,

$$[\pi_1, \pi_2, \dots, \pi_K] \sim Dirichlet(c_1 + y_1, c_2 + y_2, \dots, c_K + y_K).$$

Hence, the posterior point estimates of $\pi_1, \pi_2, \dots, \pi_K$ are simply

$$\hat{\pi}_i = \frac{c_i + y_i}{\sum_{j=1}^{K}(c_j + y_j)}.$$

Posterior estimates of standard deviations and credible intervals for all π_i could, in theory, be computed directly from the posterior Dirichlet distribution using numerical integration. We choose to compute standard deviations and credible intervals via MCMC sampling in the JAGS software.

The Ratio Updating Scheme

The 'amount' of update or 'smoothness' of annual changes in species composition ratios depends on the sum of counts in the prior information (i.e., $\sum^i c_i$). If $\sum^i c_i$ is large relative to $\sum^i y_i$, posterior estimates of π_i will be relatively insensitive to field data (small 'amounts' of update). If $\sum^i c_i$ is small relative to $\sum^i y_i$, posterior estimates of π_i will be relatively sensitive to field data (large 'amounts' of update). Furthermore, nothing in the statistical theory indicates the appropriate 'amount' of update.

The updating scheme proposed here assumes that species composition ratios will vary significantly during MidAmerican's HCP period. We desire accurate species ratios during any particular year, yet recognize that little data (few carcasses) will be collected during a given year. We designed the updates to be sensitive to changes in species composition ratios through time, and to yield non-zero proportions with as much certainty as possible. The species composition ratio update scheme scales past annual pseudo-counts to have a declining amount of influence on current estimates. In this way, current data is weighted most heavily, but past data also plays a role when few or no carcasses of a rare species are found.

The updating scheme proceeds as follows. Assume that the field season in year j is just complete. Assume further that a total of C_{j-1} carcasses (all species, rare + other) were found in year $j-1$, C_{j-2} carcasses were found in year $j-2$, and so on. We estimate composition ratios for use in year j by first scaling the total pseudo-count in previous years (i.e., years $j-1$, $j-2$, ..., 1) to a declining fraction of count in the most recent past year (year $j-1$). We then apply the Bayesian updating procedure described above. After scaling by declining weights, the Bayesian updating scheme simply sums the scaled pseudo-counts for each species and divides by the total (because the Dirichlet is a conjugate prior).

The weights applied to prior pseudo-counts are derived from the shape of the normal distribution. When used in this way, the normal distribution is said to be a 'kernel' function which smoothes species composition information through time. Other kernel functions could be used. Depending on the standard deviation parameter (σ) of the normal distribution, the kernel can either average many years (i.e., lots of smoothing when σ is large) or average few years (i.e., little smoothing when σ is small). σ

When more weight is assigned to recent data, the composition ratios will respond quickly to changes in the composition of carcasses. When more weight is assigned to past data, composition ratios respond more slowly to changes in carcass composition but will be more stable and reflect long-term quantities. Unfortunately, there are no statistical guidelines for how much weight to assign current data. MidAmerican will assign weights so that >90% all weight is assigned to the most recent 5 years of data (excluding the current). This 'amount' of smoothing will allow composition ratios to respond to anticipated change drivers, such as white-nose syndrome (WNS) and climate change, which generally affect changes over time periods of 5 years or more.